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(19) (CA) # CANADIAN PATENT

(54) PELLETIZING ORES AND CONCENTRATES

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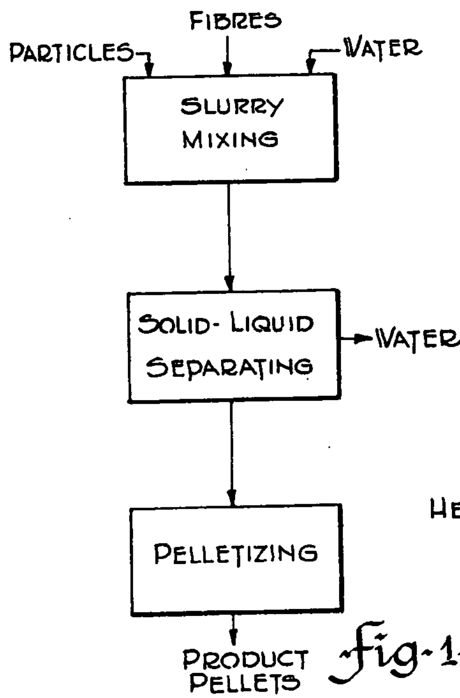
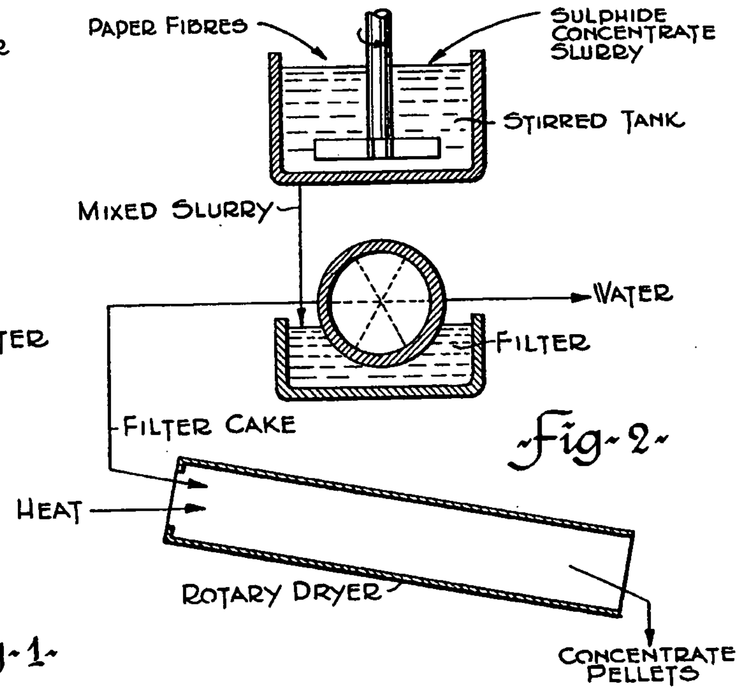


-Fig-1-



-Fig-2-

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The pelletizing of ores and concentrates is widely practised as a means to prepare such materials for subsequent treatment in the recovery of metal values. In the treatment of sulphide concentrates, for example, pelletizing is a common practice prior to sintering on horizontal travelling grate machines. Without pelletizing, or some other form of agglomeration, the sinter bed is generally not sufficiently porous to allow enough draw of air through the bed to establish adequate temperatures for satisfactory sintering at practicable rates. Pelletizing is also effected in the preparation of finely divided materials for treatment in shaft furnaces and rotary kilns, although in such cases it is commonly necessary to strengthen the green pellets by thermal induration, without which the pellets could not withstand the weight imposed on them in a shaft furnace or the abrasive movement present in a rotary kiln. Improvements in a pelletizing operation that would render such thermal induration unnecessary are clearly advantageous, but in any case it can be said in general that the stronger green pellets can be prepared initially, the more readily and efficiently they can be handled and treated subsequently, whatever the treatment might be.

While pelletizing techniques vary from one material to another because of the unique pelletizing characteristics of each particle type, there are certain means that can be adopted with advantage in many different pelletizing operations. The use of bentonite, for example, is advantageous as a binder in the pelletizing of a wide variety of materials and other binders with broad applications have also been described.

Among such binders are fibrous materials, both organic and inorganic, which have been added to various materials prior to pelletizing and are said to provide certain advantages. Thus in Canadian Patent 778,712 a process is described in which peat moss is mixed with moist iron ore particles, the mixture is pelletized and the resulting pellets are then heated to dry and harden them.

During heating, the peat moss fibres are said to shrink and thereby provide channels for the escape of water vapour from the pellets so that they may be dried and hardened without spalling. The only description regarding the means of preparing the pellets, however, is the statement that the "short, tiny fibres (of peat moss) can be .... picked up with the ore when placed in a pelletizing drum or disc," and elsewhere in the patent is the statement that "pellets made with peat moss have a somewhat lower compression strength than the others (without additives)".

Another process is described in Canadian Patent 777,729 in which inorganic fibres, such as asbestos, rock wool and glass, are mixed with iron oxide ore concentrates and the mixture is then pelletized. Similar advantages are claimed for these pellets as in the patent above, and in addition they are said to have increased green or "wet" strength. There is no reference to the method of mixing, however, but it is stated that "Other than asbestos, both inorganic and organic fibrous materials were difficult to disperse and mix with the ore concentrate". In addition, it is also stated that "organic fibre-containing pellets, though exhibiting good "green" or wet strength, failed to satisfactorily endure firing".

These patents reflect the present state of the art regarding the use of fibrous materials in pelletizing, and lack description not only of the means of mixing the fibres with the material to be pelletized, but also of means to make pellets of improved properties with organic fibres.

A method is now available according to the teachings of the present invention, however, whereby fibres in general and organic fibres in particular, notably cellulosic wood fibres such as those of various paper products and textile fibres such as wool, rayon and nylon, are used in the preparation of pellets of improved properties. The use of organic fibres has met with more success

in the present case than in the past because of the improved method described herein for the mixing of the fibres with the particles to be pelletized and for the pelletizing of the resulting mixture.

Summary

In the process of the invention pellets of solid particles, such as particles of ores or mineral concentrates, are produced by preparing an aqueous slurry of the particles and blending fibres into the slurry to form a mixture of particles, water and fibres. Advantageously, wood fibres, such as those in paper, kraft screenings and like products of the pulp and paper industry and textile fibres, such as wool, rayon, nylon and the like are used. Water is removed from the mixture to form a moist mixture of particles and fibres and the moist mixture is pelletized to form fibre-bearing pellets having improved strength and mechanical stability and increased thermal shock resistance.

Broadly stated, the invention comprises mixing the fibres and the particles as an aqueous slurry, separating the slurry water from the mixture of particles and fibres, and pelletizing the mixture. In those cases in which the separation of water and solids does not result in a mixture sufficiently dry to pelletize directly, the invention additionally comprises partially drying the mixture in a rotary dryer and simultaneously pelletizing the mixture under the rolling action of the dryer.

Thus the success of the present method depends primarily on mixing the fibres and particles as an aqueous slurry. It is impracticable if not impossible to achieve a sufficiently homogeneous mixture for preparation of pellets of improved properties if the blending is not carried out in a slurry. Another essential feature, in some cases, is the simultaneous drying and pelletizing of the mixture by exploiting the combined influence of the heating effect and rolling motion of a rotary dryer.

By the advantageous combination of operations constituting this invention, pellets are made that are not only stronger and more amenable to the penetration of heat and gases than similar pellets without fibres, but also contain as little as about 0.3 to 1% only of the fibre binder. While the method was developed primarily for use with organic fibres such as those of paper, it applies as well to any fibre that would be used as a binder in pellets. The quantity of fibre required and the properties of the resulting pellets might vary from one fibre type to another but the present method can be advantageously applied to make better pellets of given particulate solids than can be made with a given fibre by existing methods.

Various objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawing.

Brief Description of the Drawing

Figure 1 is a schematic flow diagram showing the broad essential elements of the present pelletizing method; and

Figure 2 is a schematic flow diagram showing a more specific embodiment of the present invention.

Description of the Preferred Embodiments

Referring first to Figure 1, it is seen that the invention consists essentially of three unit operations, slurry mixing, solid-liquid separating, and pelletizing. The essential requirement for slurry mixing is an aqueous suspension of the particles and the fibres. This can be established conveniently in a vessel supplied with an agitator. The particles, fibres and water are fed to the tank separately or in any desired combination or combinations and are agitated and mixed as a slurry in the vessel to disperse and mix the fibres among the particles. The time required will vary depending on the manner in which the fibres are provided to the slurry. In the case of wood fibres, for example, somewhat longer time may be required for mixing if

the fibres are fed as chunks of paper which have to be broken up by the action of the slurry itself than if the same paper were pulped or "defibered" before being fed to the slurry. But in both cases a degree of dispersion of th fibres and homogeneity of the mixture is achieved that cannot be obtained by mixing when the particles are dry or damp or in general in a non-slurry condition.

Having obtained a substantially homogeneous mixture of fibres and particles in aqueous slurry, the bulk of the water must next be removed before the solids mixture can be pelletized. The solid-liquid separation can be effected by any means that does not result in any significant segregation of the fibres and solid particles, notably filtration. Not only is the likelihood of segregation less with filtration than with settling or centrifuging, but filtering rates themselves are higher for fibre-particle slurries than for similar particle slurries without fibres. Further reference to this phenomenon appears later in the application. The product of solid-liquid separation, by whatever means, is a wet mass of particles mixed with fibres, such as a filter cake, which serves as feed for the final stage of the process.

In the broad case shown in Figure 1, the moisture content of the solids following solid-liquid separating is low enough that the solids can be pelletized directly without further moisture removal. In this case the final stage of the process consists simply of feeding the moist solids to a pelletizing apparatus and producing pellets. The nature of the pelletizing apparatus, per se, is not critical. The superior quality of the pellets in this case is due more to the means described above for preparing the pelletizing feed than to the pelletizing operation itself. The pelletizing operation is critical, however, in those cases in which the moisture content of the solids following solid-liquid separating is too great for pelletizing without further moisture

removal, and this situation is discussed below.

Referring now to Figure 2, a more specific application of the invention is described for the pelletizing of a sulphide concentrate mixed with paper fibres. Slurry mixing is conveniently effected, as shown, by feeding the sulphide concentrate as a slurry into a stirred tank, adding the paper fibres, and agitating the mixture to disperse the fibres among the concentrate particles. Paper fibres that are suited to the present application include paper products such as newsprint, for example, and by-products and waste products of the pulp and paper industry such as, for example, kraft screenings. The latter are particularly desirable not only because they are less expensive than most paper products, but also because they are available as loosely compressed sheets that are readily repulped and dispersed under the abrasive action of the concentrate slurry. Better quality paper products generally require more time to "defiber" although the process is hastened if the paper is fed to the stirred tank in a soggy condition. It could also be repulped beforehand and fed to the mixing tank as a slurry, but such preparation certainly is not necessary and might not even be advantageous. In short, it is not critical in what form the fibres are fed to the mixing tank. In all cases the fibres themselves are approximately 1 to 4 mm in length and regardless of the form in which they are fed to the tank, mixing is carried on for long enough to separate and disperse them among the concentrate particles.

The mixed slurry is filtered, conveniently by a drum or leaf filter, an operation which, as mentioned above, is enhanced by the presence of the fibres in the mixture. Whether they behave as wicks or channels along which water moves more readily than through the interstices between the concentrate particles of the cake is not definitely known, but filtering rates for the fibre-bearing pulp are as much as double those for pulp without

the fibre and the degree of water removal is at least as great r great r than without fibres. The moisture content of such filter cakes is not low enough, however, to permit pelletizing directly and a further essential operation is therefore required.

Thus the filter cake is fed to a rotary dryer in which it is partially dried and pelletized. The significant feature of this operation is that the drying and pelletizing occur simultaneously in the same apparatus. Any mode of operation of the dryer-pelletizer is acceptable that results in lowering of the moisture content of the mass to a level at which pelletizing performance best approaches that desired. This level is conveniently established for a given particle-fibre mixture and other operating conditions by noting pelletizing characteristics over a range of moisture levels and then controlling the dryer operation to the moisture level that corresponds to the pelletizing performance desired. As in filtration, the presence of fibres in the mixture enhances the quality of the operation. It has been found that build-up on the wall of the dryer-pelletizer resulting from operation without fibres is gradually removed during subsequent operation with fibres and thereafter the wall remains clean. Thus the operation is more efficient in terms of recovery of feed to product pellets in addition to producing pellets of superior qualities, notably narrower, more even size distribution, and increased green strength and thermal shock resistance.

The pellets res"lting from the application of this invention can be charged to and recovered from conveyor belts, chutes, bins, rail cars, and other handling and transporting devices with less degradation than similar pellets without fibres, and can be heated with less spalling or other damage from thermal shock. In addition, in the case of pellets of sulphide concentrates, sintering rates on travelling grate machines are faster not only because the pellets themselves are more porous to penetration of heat and gases, but also because the sinter bed itself is more porous due

to the greater strength and mechanical stability of the pellets comprising it. Another advantage of the invention is that as little as 0.3 to 1% by weight of the fibr binder is required compared to generally larger quantities used in existing methods. Thus the present invention is characterized not only by an improved product but also by a lower unit consumption of fibre binder.

Similar remarks to those made above in regard to Figure 2 for the application of paper fibres to pelletizing according to this invention can be made also for the similar application of other organic fibres, notably textile fibres such as those of wool, rayon and nylon. As with paper fibres, such textile fibres are available as waste products of the textile industry such as wool napper waste, rayon-nylon fluff from automobile tires, and shear waste from automobile seat covers. Again, as with paper fibres, the textile fibres are of similar size and shape and have been shown to behave similarly when applied in a similar manner according to this invention for the pelletizing of ores and concentrates.

It is thought that the reason the fibres are so effective not only in the pelletizing operation but also in filtering is because of the improved means of the present invention for dispersing and mixing the fibres among the particles. It will be recognized by those familiar with the art of pelletizing that the more uniform the dispersion of a binder the more uniform and stronger the product pellets and the less the amount, and therefore the cost of the binder required to make them. By the present means the degree of homogeneity of mixing is so high that superior pellets are produced with only about 1/3 to 1% by weight of fibres in the mixture.

The practice and advantages of the invention are further documented in the following examples:

Example 1

The effect of fibre binders on the pelletizing of particulate materials according to this invention is conveniently demonstrated by comparing the results of treating a given particulate material with a fibre binder, to those of a similar treatment without the binder. For this comparison the material was mineral concentrate and the binder was a wood fibre material referred to as kraft screenings. The concentrate was typical of those derived from the sulphidic nickel deposits of the Sudbury basin and consisted primarily of pyrrhotite with lesser quantities of pentlandite and chalcopyrite, and minor concentrations of gangue constituents. Particle size was characteristically about 80% - 200 Tyler mesh. The kraft screenings were wood fibres about 3-4 mm in length, provided as damp, loosely compressed sheets. In this case about 50 tons of concentrate were slurried in water and maintained in suspension at about 55% solids in an agitated stock tank about 10 feet deep and 14 feet in diameter. About 1000 lb. of fibres, equivalent to about 1% by weight of the concentrate, were added to the slurry as pieces of the wet sheets of kraft screenings. Under the agitating action in the tank the sheets were "defibered" and the fibres dispersed and substantially homogeneously mixed with the concentrate particles in less than two hours. The mixed slurry was then filtered in a disc filter 8.5 ft. in diameter with 8 discs and about 900 sq. ft. of filter area at a rate of about 22 dry tons per hour of concentrate compared to only about 17 tph without paper. The filter cake, which fell cleanly from the discs of the filter, contained about 14% free moisture, compared to about 15% or more in a similar treatment without fibres. The filter cake was then charged to a co-current, oil-fired rotary dryer 7 ft. in diameter and 36 ft. long rotating at about 4 rpm, and was partially dried, and simultaneously pelletized during a retention time of about 5 minutes. The dust loading in the dryer off-gases was less than 0.5 lb./min. compared to about 33

lb./min. for a similar operation without the fibres. The product pellets contained about 8.7% free moisture and had a more uniform pellet size distribution than that of pellets prepared in a similar manner but without paper, as shown in Table 1.

Table 1

SIZE DISTRIBUTION OF Ni-Cu SULPHIDE CONCENTRATE PELLETS WITH AND WITHOUT PAPER

Binder	Pellet Size, 0.5"	Cumulative % 0.25"	Larger Than 0.1"
1% kraft screenings	15	46	99
None	8	28	65

The quality of the pellets was further indicated by the measurement of several properties of the pellets in various conditions, as described below.

The drop strength was the percentage of 2500 g of -3/4" +3 Tyler mesh green pellets that was still +3 Tyler mesh in size after the pellets had been dropped 4 times from a height of 4 feet into a wooden box.

The crushing strength of the pellets was the average weight in pounds required to crack or break at least 6 pellets placed successively between two flat plates and compressed by gradually increased weights until failure occurred. This test was applied to green, aged, and dried pellets. Aged pellets were green pellets that had been left in the open air for several days and dried pellets were green pellets that had been heated in an oven at 110°C for 1 hour.

Thermal shock resistance was the weight percentage of six 1/2" diameter green pellets that was +3 Tyler mesh in size after the pellets had been placed in a wire basket, quickly lowered into a vertical tube furnace at 900°C, heated in a nitrogen atmosphere for 4 minutes and then removed and cooled in

nitrogen. The relative quality of pellets both with and without paper, as indicated by the measurements described above, is shown in Table 2.

Table 2

QUALITY OF Ni-Cu SULPHIDE CONCENTRATE PELLETS WITH AND WITHOUT PAPER

Test	Binder	
	1% kraft screenings	None
Drop Test, % +3 Mesh	96	58
Crushing Strength,		
lb. green	7.5	4.5
aged	8.4	5.1
dry	11.5	7.5
Thermal Shock		
Resistance, % +3 Mesh	100	25

Compared to pellets with no fibres, the fibre-bearing pellets were handled on conveyor belts and through bins with less breakdown and production of fines, and were sintered as much as 30% faster on horizontal travelling grate machines. The improvement in sintering rate was due presumably both to the increased porosity of the pellet bed resulting from the lower concentration of fines, and also to the increased porosity of the individual pellets comprising the bed.

Example 2

A similar increase in sintering rate to that cited above was also obtained with considerably less than 1% fibre in the pellets. Thus in one operating period of three months during which sulphide concencrate was pelletized without fibre, the sintering rate averaged 10 tons per sintering machine hour, while in another three month period, during which conditions were similar except for the presence of 0.34% kraft screenings in the pellets, the sintering rate average 13.2 tons per machine hour, an increase of over 30%.

Example 3

Further evidence of the effect of fibre on filtering rate of concentrate slurry is provided by the results of a 48 hour test in which 0.75% kraft screenings was added to the concentrate slurry according to the teachings of this invention. During the preceding 48 hour period, the filtering rate of the concentrate slurry without fibre was 4.0 tons per filter hour while during the 48 hour test period with fibre the filtering rate averaged 8.1 tons per filter hour, more than double the previous rate.

Example 4

In another case the filtering rate without fibre was 10 tons per filter hour while the addition of 0.3% kraft screenings to the slurry raised the filtering rate to 14 tons per filter hour.

Example 5

Similar results were achieved with newspaper fibres as with kraft screenings, as indicated by the properties of sulphide concentrate pellets both without fibres and with either newspaper or kraft screening fibres as shown in Table 3.

Table 3

QUALITY OF PELLETS WITH DIFFERENT PAPERS AND NO PAPER

Properties	Binder 1% Kraft Screenings	1% Newsprint	None
% H_2O in pellets	9.2	9.0	7.8
Drop Test, % +3 mesh	99.1	98.8	79.0
Crushing Strength, lb. green	9.1	8.1	5.1
dry	21.2	11.1	7.5
Thermal Shock Resistance % +3 mesh	100	100	74

It is clear that the properties of the fibre-bearing pellets were similar to one another and markedly superior to those of similar pellets without fibre.

Example 6

The invention applies also to materials other than sulphide concentrates. Thus in this particular case paper pulp additions were made to a slurry of iron oxide particles resulting from the roasting of a pyrrhotite concentrate and following partial drying and pelletizing in a rotary dryer, the effect of paper concentrations between zero and 1% was assessed by drop tests with the qualitative observations shown in Table 4.

Table 4

QUALITY OF IRON OXIDE PELLETS WITH PAPER

Test No.	Paper Wt. %	Results of Drop Test
1	0	excessive fines generation
2	0.25	slight fines generation
3	0.50	no pellet breakage
4	0.75	no pellet breakage
5	1.00	no pellet breakage

Thus it is seen that improved drop strength resulted from as little as 0.25% paper and that substantially no pellet breakage occurred at all with 0.5% paper or more added to the iron oxide according to this invention.

Example 7

The application of fibres other than paper for pelletizing of finely divided solids is illustrated by the present example in which mixtures of 1% by wt. of various fibres in copper-nickel sulphide concentrate similar to that referred to in previous examples were prepared and pelletized according to this invention. The green crushing strength and drop strength of the resulting pellets are compared to those of pellets made with 1% by wt. of paper fibre and to other pellets with no fibre content at all, as shown in Table 5.

Table 5

QUALITY OF SULPHIDE CONCENTRATE PELLETS WITH VARIOUS FIBRES

Fibre Additive	Moisture in Pellets Wt. %	Crushing Strength Green, lb.	Drop Strength No. of Drops *
Nil	8.6	1.2	10.3
Paper	9.6	3.8	25.8
Nylon-Rayon Fluff	9.8	3.5	43.6
Wool Napper Waste	8.8	3.5	52.1
Wool Shear Waste	9.0	3.4	21.5

* Number of 20" drops onto concrete before breakage.

It is clear that the strengths of the fibre-containing pellets were all notably greater than those of the pellets without fibres, although the paper-bearing pellets had a somewhat higher crushing strength than the others, while the pellets containing wool napper waste had the greatest drop strength.

While rotary drying and pelletizing, as described for a specific case with reference to Figure 2, was applied in all the examples above, the broader method, as described in relation to Figure 1, can be applied to solids, such as natural iron ore concentrates which generally have a coarser, more uniform particle size than the sulphide concentrates and iron oxide calcine described above, and can therefore be filtered from a slurry to a sufficiently low moisture concentration for direct pelletizing without further moisture removal. In the specific case of iron ore concentrates, for example, it is well known that in general these materials, in slurry form, are simply filtered and fed directly to disc pelletizers without any intermediate drying. Such solids are clearly ideally suited for treatment according to the broad aspects of this invention as described in Figure 1.

The embodiments f the inventi n in which an exclusive pr perty or privilege is claimed are defined as follows:

1. A method for producing pellets of solid particles comprising,

(i) preparing an aqueous slurry of particles selected from the group consisting of ores, ore concentrates and mineral concentrates,

(ii) blending fibres selected from the group consisting of wood fibres and textile fibres into the slurry thereby forming a mixture of particles, water and fibres,

(iii) separating water from the mixture thereby forming a moist mixture of particles and fibres, and

(iv) pelletizing the moist mixture thereby forming fibre-bearing pellets of improved properties relative to those of similar pellets devoid of fibres.

2. Method according to claim 1 in which the particles are iron ore concentrate particles.

3. Method according to claim 2 in which the fibres are wood fibres selected from the group consisting of paper, kraft screenings and like products of the pulp and paper industry.

4. Method according to claim 1 in which the fibres are textile fibres selected from the group consisting of wool, rayon, nylon and the like.

5. Method according to claim 1 in which the moist mixture of particles and fibres is too moist for pelletizing and additionally comprising, partially drying the moist mixture in a rotary dryer and simultaneously pelletizing the partially dried mixture under the rolling action of the dryer.

6. Method according to claim 5 in which the particles are selected from the group consisting of sulphide concentrate and materials derived from sulphide concentrates and the fibres are selected from the group consisting of wood fibres and textile fibres.

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7. Method according to claim 6 in which the fibres are wood fibres selected from the group consisting of paper, kraft screenings and like products of the pulp and paper industry.

8. Method according to claim 6 in which the fibres are textile fibres selected from the group consisting of wool, rayon, nylon and the like.

9. Method according to claim 6 in which the particles are selected from the group consisting of nickel-copper sulphide concentrates, nickel-copper oxide calcines derived from roasting nickel-copper sulphide concentrates, and iron oxide calcines derived from roasting iron sulphide concentrates.

10. A method for producing pellets of nickel-copper sulphide concentrate particles comprising,

(i) preparing an aqueous slurry of the particles,

(ii) blending paper fibres into the slurry thereby forming a mixture of the particles, water and fibres,

(iii) filtering the slurry thereby producing a moist filter cake of mixed concentrate particles and paper fibres,

(iv) partially drying the filter cake in a rotary dryer and simultaneously pelletizing the partially dried filter cake under the rolling action of the dryer, thereby forming paper fibre-bearing pellets of improved properties relative to those of similar pellets devoid of paper fibres.

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